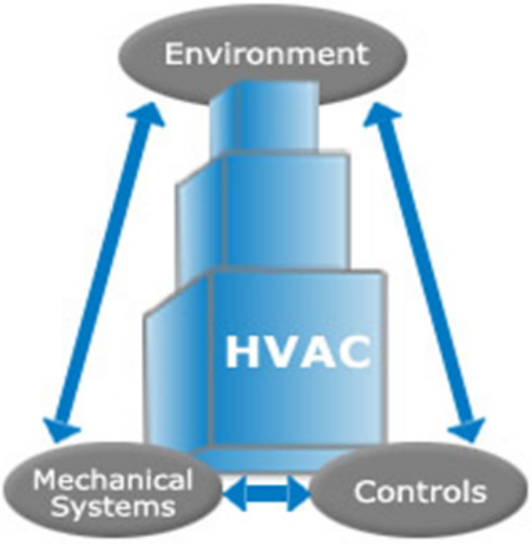
Session 10

CPD Seminar

Mechanical Ventilation and Air-Conditioning

1 February, 2013

Three Key Elements of a MVAC System



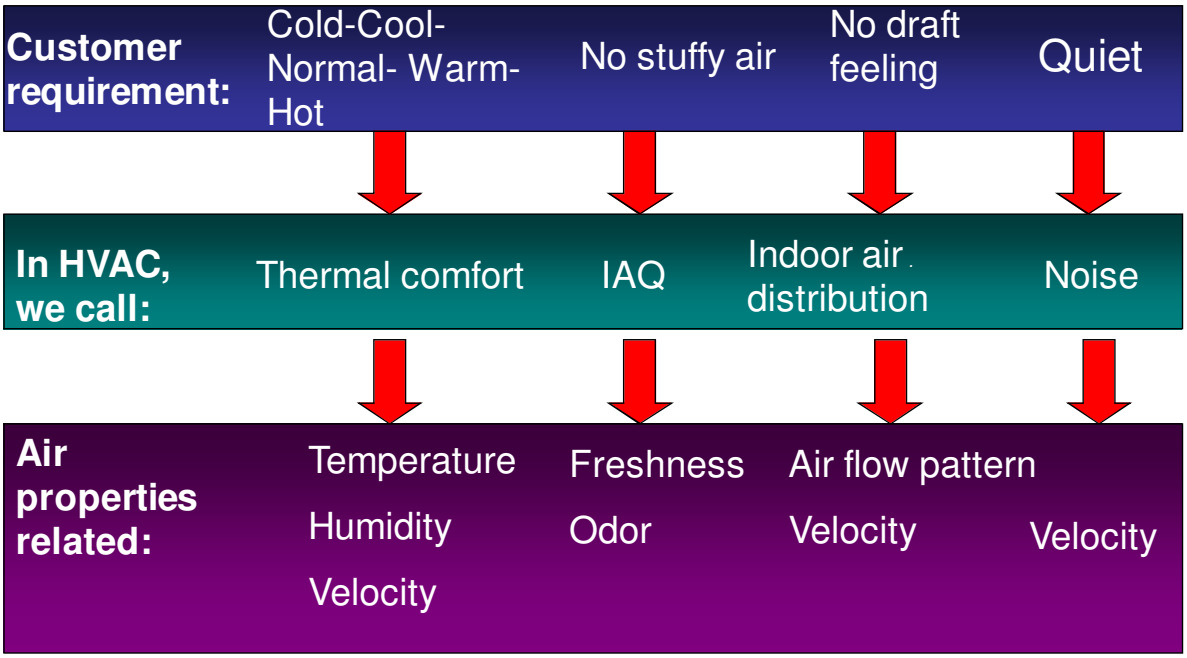
Environment refers to the customer indoor air environment requirement.

Mechanical Systems refers to a set of mechanical equipment, which serve as source, distribution and terminal function.

Controls refers to control components that monitor and regulate the performance of mechanical system.

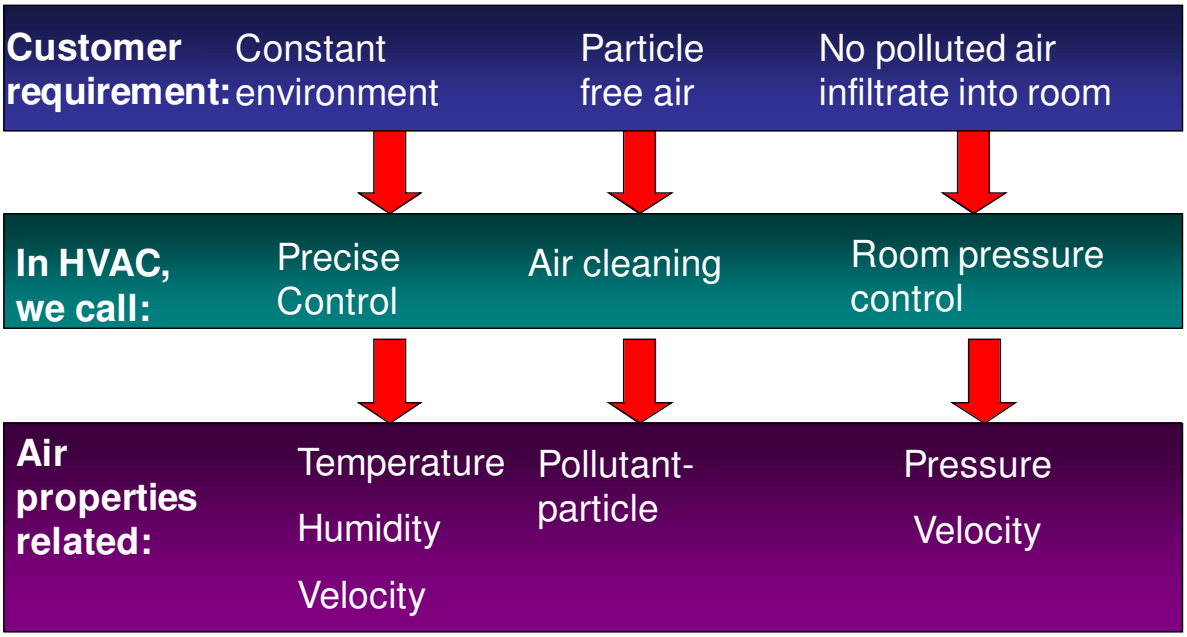
Customer Indoor Environment Requirement

For occupants comfort:



Customer Indoor Environment Requirement

For industrial process- clean rooms for chips:



Customer Indoor Environment Requirement

For industrial process- hospital operating rooms:

Customer requirement	Comfort environment	Bacteria free air	No polluted air infiltrate into room	No polluted air circled in the room
In HVAC, we call:	Thermal comfort	Bio-cleaning	Room pressure control	Indoor Pollutant Control
Air properties related:	Temperature Humidity Velocity	Pollutant-bacterial, virus	Pressure Velocity	Air flow pattern Velocity

P-H Diagram

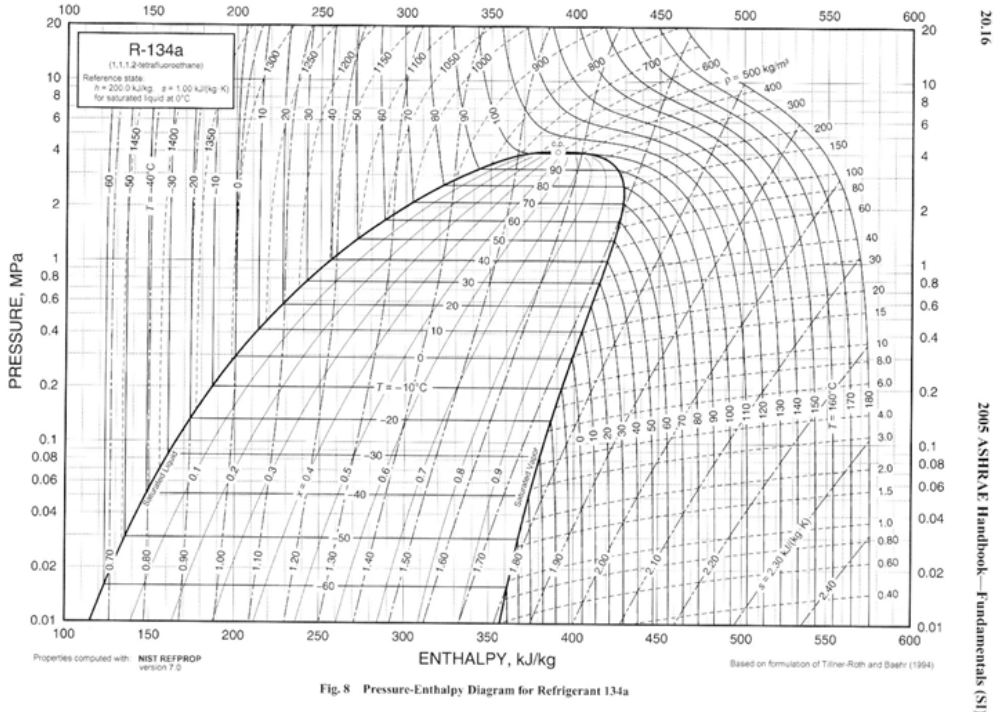
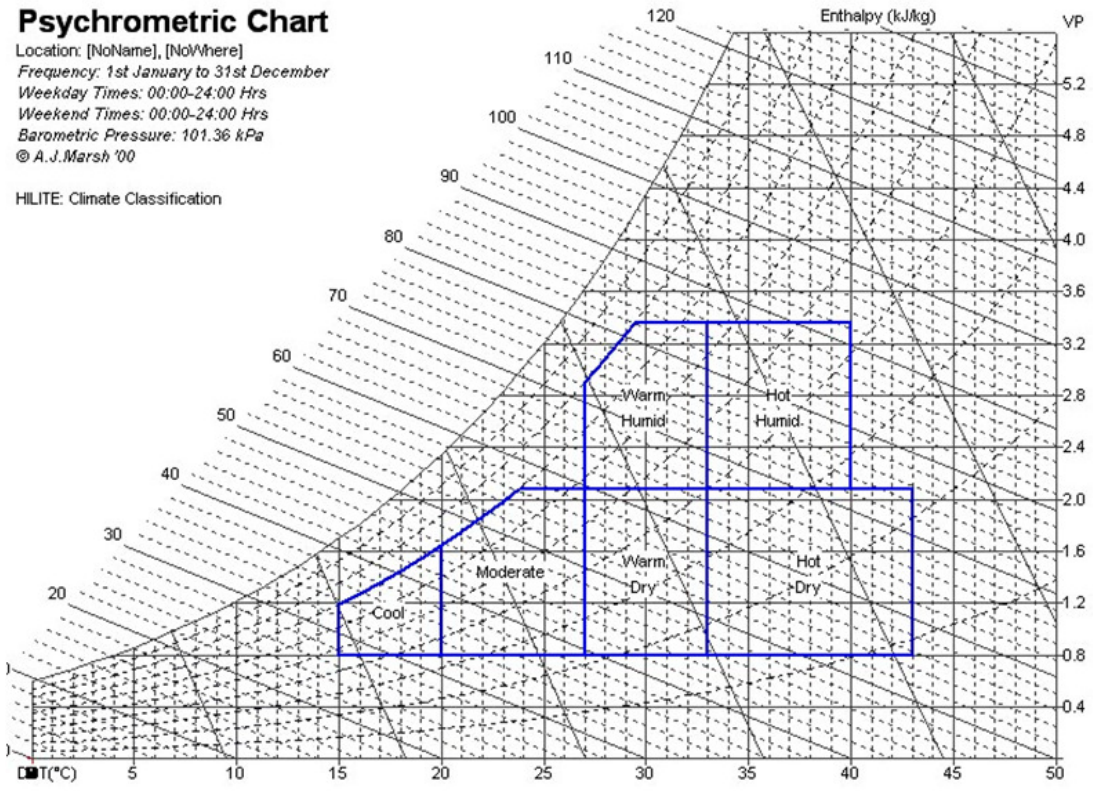


Fig. 8 Pressure-Enthalpy Diagram for Refrigerant 134a

Psychometrics – Climate



Comfort

- In any subjective assessment of the comfort of the whole environment, thermal, acoustic and visual factors all play a part.
- All 3 aspects need to be considered together since the means of providing one component may influence the design of another.
- It is not possible to formulate a single index which quantities the personal response to the whole environment.

Thermal Comfort

- In a **first-class AC** system one is not really conscious of the temperature or humidity because he is comfortable.
- Comfort zone varies with activities and with season
- Different individuals require different comfort zone (due to age, sex, race and degree of acclimatization)
- Man as source of heat:

- seated at rest	115W
- Light work	140W
- Walking slowly	160W
- Dancing	265W

Thermal Comfort

- Dry bulb temperature –air temperature
- Wet bulb temperature
- Relative humidity
- Air velocity
- Mean Radiant temperature
- Resultant temperature

✓ inside a 100mm dia. black globe

✓ devised by A. Missenard in 1935

✓ $= 0.6t_a + 0.4t_r$ where air velocity is 0.35 m/s

- Obsolete comfort measurements include: Globe temperature (150mm dia.), Equivalent temperature & effective temperature

Thermal Comfort

Conditions leading to thermal comfort:

- RH:
  - lies within 30 to 70%
- Velocity
  - Upper limits: 0.15 m/s at 20^0C and 0.45 m/s at 25^0C
  - Lower limits: 0.1 m/s at 20^0C and 0.2 m/s at 25^0C

Thermal Comfort

- Mean radiant temperature:
  - comfort cannot be achieved if the m.r.t. is $>8^0$C above or $<5^0$C below air temperature
- Resultant temperature:
  - between 19^0C and 23^0C

Thermal Comfort

Predicted Mean Vote

- Developed by Professor P. O. Fanger in 1970
- PMV can be calculated using 6 parameters:
  1. Metabolic rate
  2. Clothing
  3. Dry bulb temperature
  4. Humidity
  5. Radiant temperature
  6. Air speed
- Comfortable if PMV is 0
- Warm or hot if PMV is positive (1, 2, 3)
- Cool or cold if PMV is negative (-1, -2, -3)

Measuring Human Thermal Comfort Level

$$f(M, I_{cl}, V, t_r, t_{db}, P_s) = 0$$

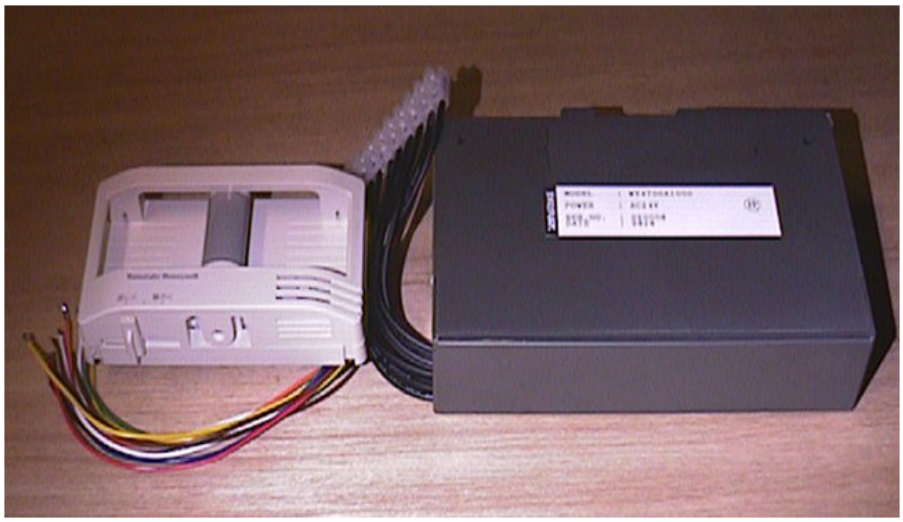
$$PMV = [0.303\exp(-0.036M) + 0.028]$$

$$\left\{ \begin{array}{l} (M-W) - 3.05\cdot 10^{-3}\cdot[5.733 - 6.99(M-W) - p_a] - 0.42[(M-W) - 58.15] \\ -1.7\cdot 10^{-5} M(5.867 - p_a) - 0.0014M(34 - t_a) \\ -3.96\cdot 10^{-8} f_{cl}\left[(t_{cl}+273)^4 - (\bar{t}_r+273)^4\right] - f_{cl}h_c(t_{cl} - t_a) \end{array} \right\}$$

$$t_{cl} = 35.7 - 0.028(M-W) - I_{cl}\left\{3.96\cdot 10^{-8} f_{cl}\left[(t_{cl}+273)^4 - (\bar{t}_r+273)^4\right] + f_{cl}h_c(t_{cl} - t_a)\right\}$$

$$h_c = \left\{ \begin{array}{l} 2.38\cdot|t_{cl} - t_a|^{0.25} \; for \;\; 2.38\cdot|t_{cl} - t_a|^{0.25} > 12.1\sqrt{v_{ar}} \\ 12.1\sqrt{v_{ar}} \quad for \;\; 2.38\cdot|t_{cl} - t_a|^{0.25} < 12.1\sqrt{v_{ar}} \end{array} \right\}$$

$$f_{cl} = \left\{ \begin{array}{l} 1.00 + 1.290 I_{cl} \quad for \;\; I_{cl} \le 0.078 m^2 K/W \\ 1.05 + 0.645 I_{cl} \; for \;\; I_{cl} > 0.078 m^2 K/W \end{array} \right\}$$



A Comfort Sensor from Yamatake

Part of PMV - Predicted Mean Vote

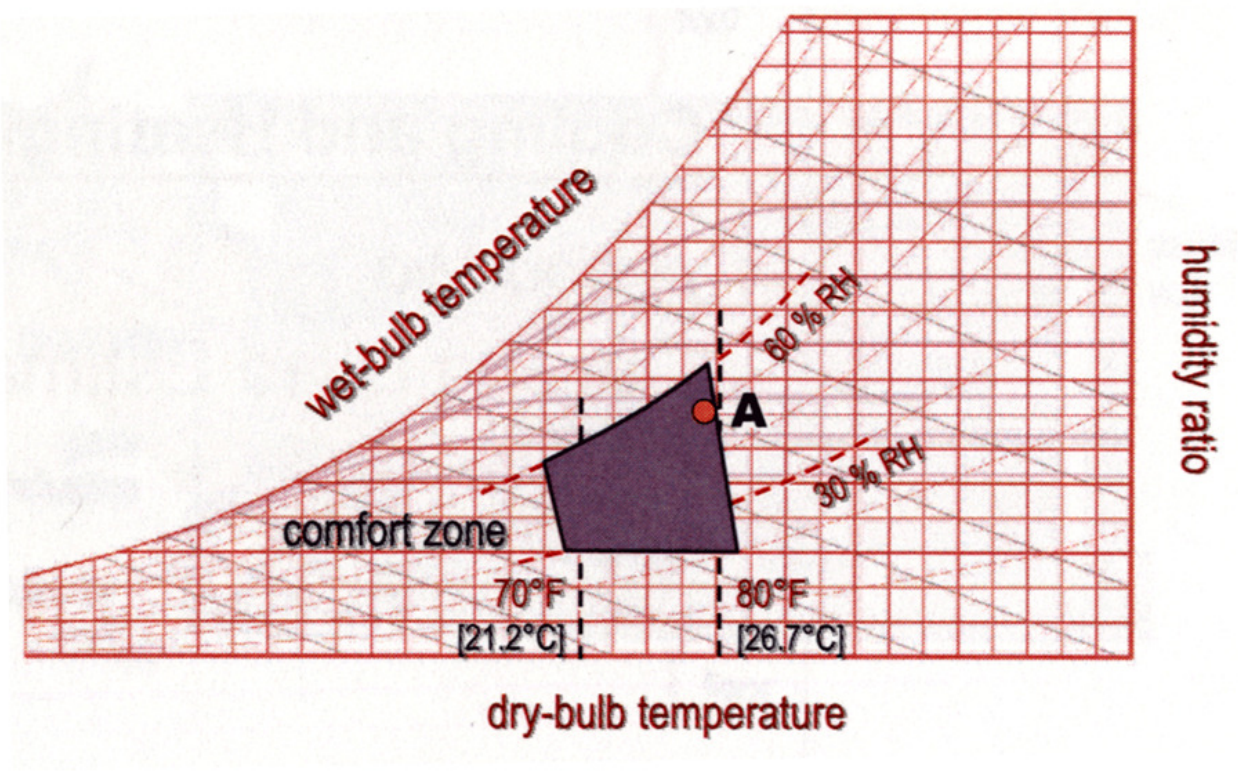
Thermal Comfort

BS EN ISO 7730 (2005)

- Make reference to PMV
- Predicted percentage dissatisfied (PPD)
  - 75% dissatisfied for PMV = 2 or -2
  - 25% dissatisfied for PMV = 1 or -1
  - 5% dissatisfied for PMV = 0
- Offices will be comfortable if operative temperature is 24.5^0C +/- 1^0C
- Operative temp = $At_a + (1-A)t_r$

Velocity	< 0.2 m/s	0.2 to 0.6	0.6 to 1
A	0.5	0.6	o.7

Psychometrics – Comfort Zone



Images credit:
Trane (2000), Cooling and Heating Load Estimation, A Trane Air Conditioning Clinic

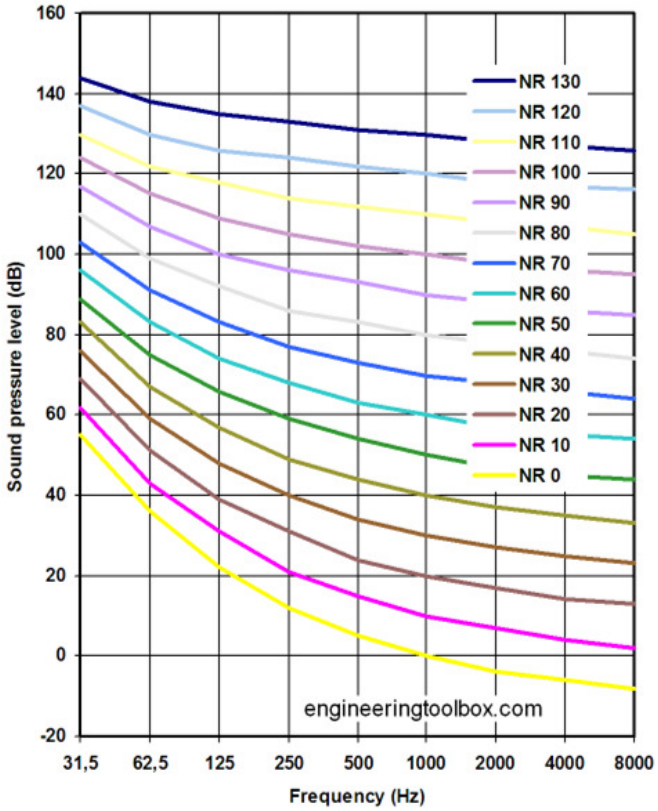
Acoustic Issues

- The ear responds to frequencies in the range of 15 to 20 000 Hz
- The response of the ear is non-linear. At low frequencies it is less sensitive
- Sound unwanted by the recipient is termed noise
- It is intermittent character of the noise not merely the noise level which causes annoyance and distraction

Acoustic Issues

Recommended noise ratings:

- Concert hall, studio - NR 20
- Bedroom, large lecture room - NR 25
- Library, small lecture room - NR 30
- Office, classroom - NR 35
- Open office, department store - NR 40
- Kitchen, canteen, pool - NR 45



Acoustic Issues

- NR 50 will generally be regarded as very noisy by sedentary workers.
- Higher noise levels than NR 50 will be justified in certain manufacturing area
- Exposure to noise levels >NR 85 can cause hearing damage
- dBA = NR + 6 (± 2)
- Acoustic treatment for chillers, pumps, fans, compressors and air handling units (AHU)

Health Issues

- Legionnaires Disease

  - disease transmitted by water droplets inhaled by occupants
  - cooling tower cleaning
  - water treatment by regular chemical
  - proper positioning of air intake louvers
  - avoid dead leg of water pipes
  - hot water temperature to be above 60^0C

Health Issues

- Adequate fresh air – e.g. for office: 8 l/s per person (Min. 5 l/s per person or 1.3 l/s per m^2
- Good air filter and filter frame (details later)
- Volatile organic compound (VOC)
- Bacteria in the air (details later)
- Bathroom ventilation – SARS consideration
- Exhaust consideration

Indoor Air Quality

- Voluntary IAQ programme by Environment Protection Department
- 12 parameters to be controlled
- More than 100 buildings registered by EPD
- Difficult to comply with and expensive to sustain.
- Most designers target on 4 to 5 parameters, e.g. T, RH, filter efficiency (by particle count), CO^2, bacteria count

Environmental Issues

- Control of ozone depletion substances (Montreal Protocol): CFC, HCFC, HFC
- Green house gases issues (global warming)

  - Rio Earth Summit 1992 under UN Framework Convention on Climate Change (UNFCCC)

  - Kyoto Protocol in 1997 (COP-3 Conference of Parties-3): Richest countries committed to 5.2% reduction of GHG emissions below 1990 level by year 2008-2012, expiry by end of 2012

  - Climate Talks at Doha on 8 Dec, 2012 yielded commitment to ambitious, but unclear, actions, Kyoto Protocol weakly extended to 2020

  - Obama pledged to reduce American emissions 17% below 2005 levels by 2020, but blocked at Senate

History of HVAC in HK

- Early 60's – Only prestigious offices have AC; natural ventilation and fans are the norm for most offices
- Mid 60"s – AC by room coolers (Weatherite)
- 70's – Chiller, AHU, refrigerant pipes, etc. are designed as component parts and assembled on site.
- 80's – package units e.g. package chiller, AHU

History of HVAC in HK

- Mid 80's – electronic control leading to CCMS
- 90's– Intelligent buildings, VAV
- 21st Century – Energy efficiency, Sick building syndrome, Remote control, VRV

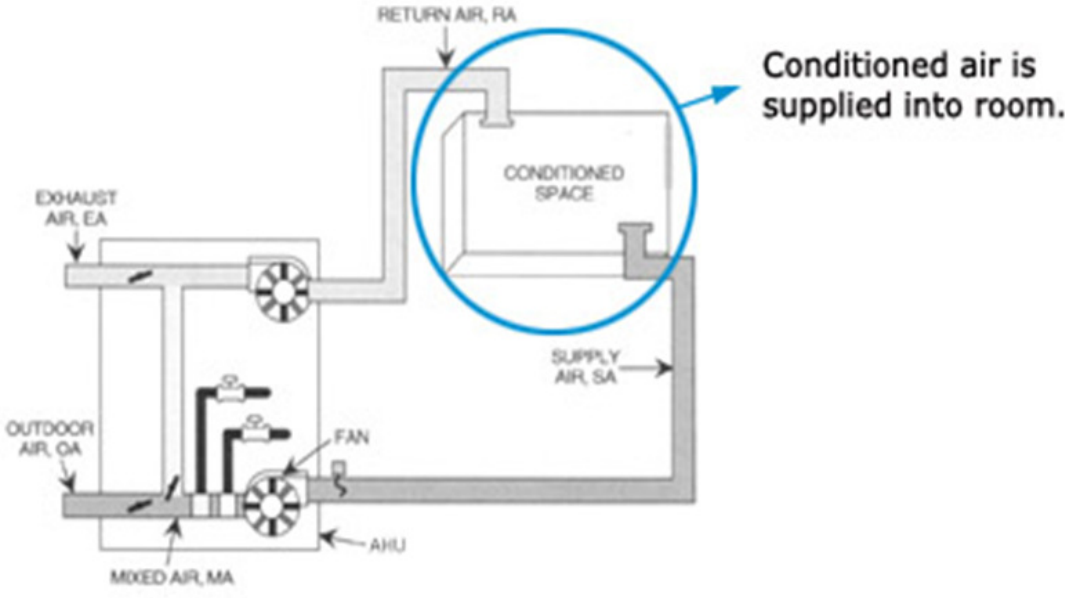
The Classification of HVAC Mechanical System

The most popular classification method used by ASHRAE is according to the **cooling/heating medium** supplied into room to condition the space.

- All-Air HVAC System
- All-Water HVAC System
- Air + Water HVAC System
- Refrigerant Direct Expansion HVAC System

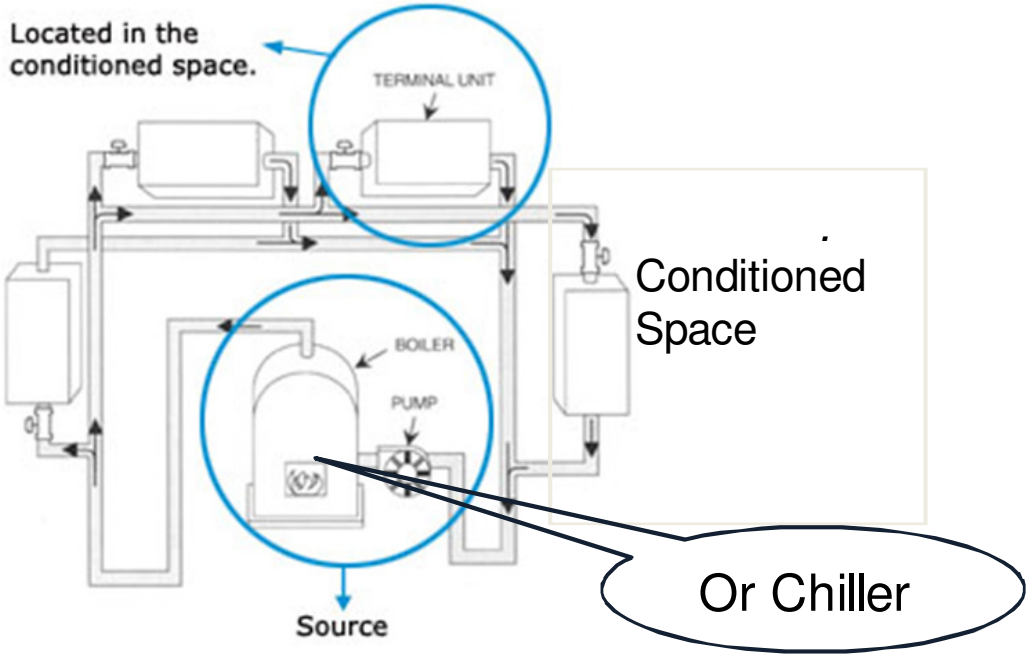
The Classification of HVAC Mechanical System

All-Air HVAC System– Only treated air is supplied to the room as cooling/heating medium to condition the space.



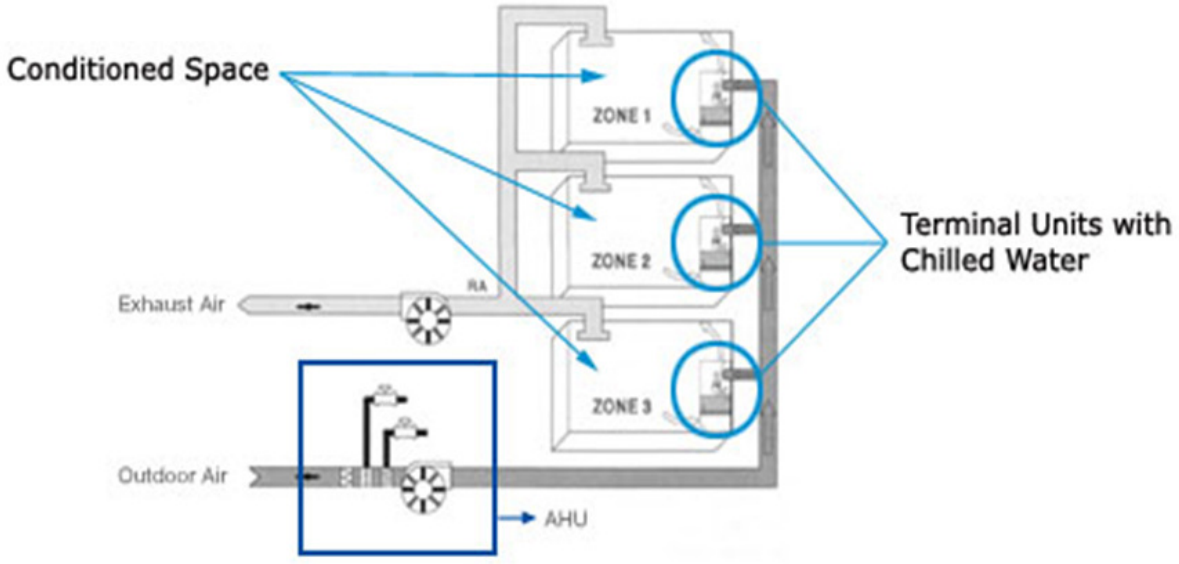
The Classification of HVAC Mechanical System

All-Water HVAC System– Only chilled/hot water is supplied to the room as cooling/heating medium to condition the space.



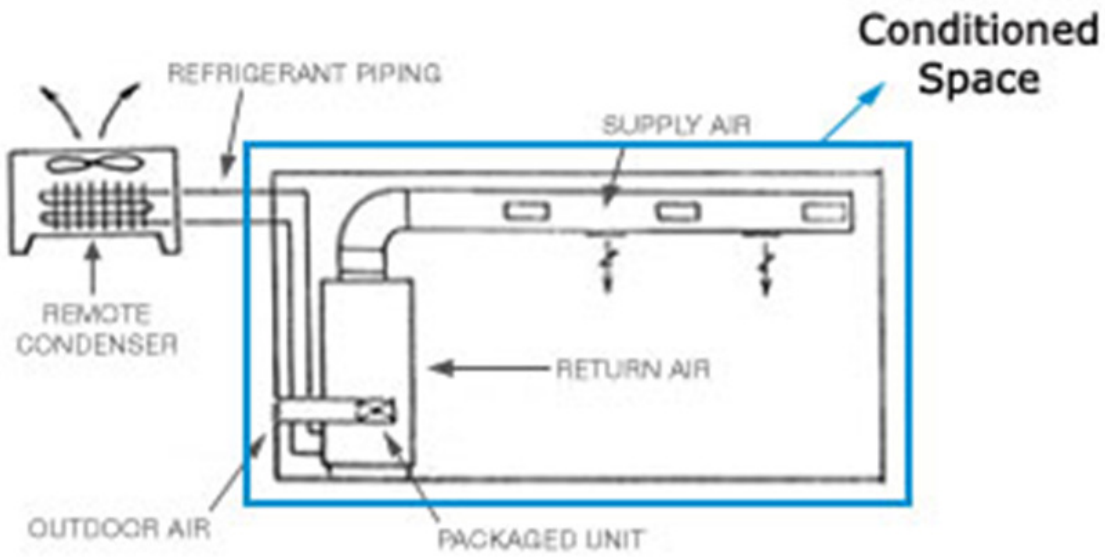
The Classification of HVAC Mechanical System

Air+Water HVAC System– Both water and air is supplied to the room as cooling/heating medium to condition the space.



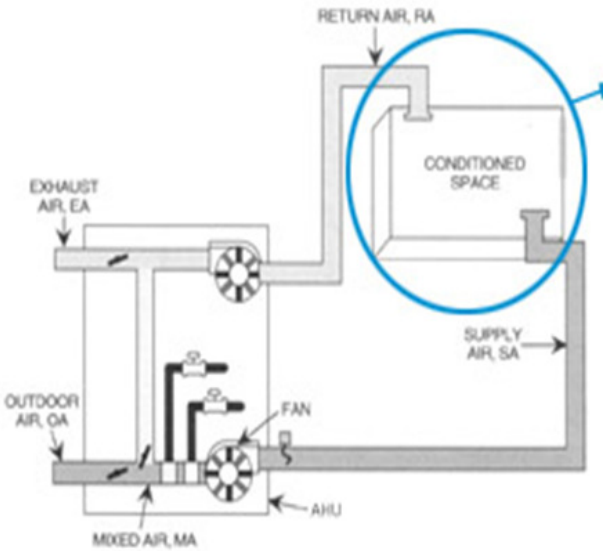
The Classification of HVAC Mechanical System

Refrigerant Direct Expansion HVAC System–
The evaporator / condenser of a refrigeration system is directly put into a room to condition the space.



HVAC Mechanical System Functions

All-Air HVAC System



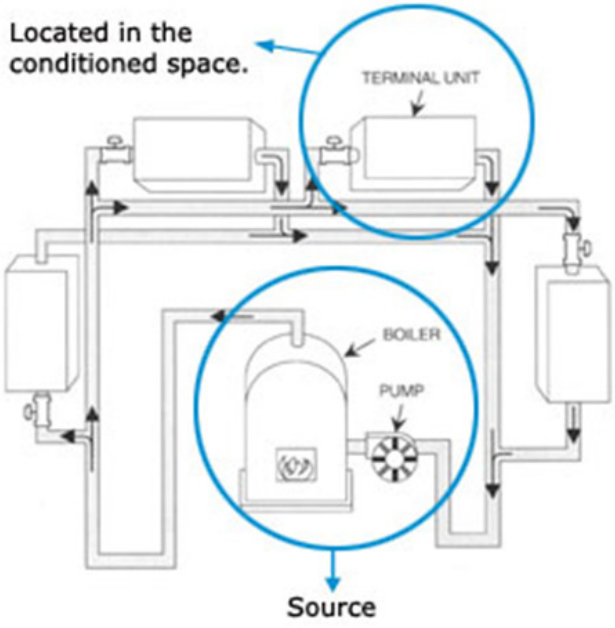
Source ?

Distribution ?

Terminal ?

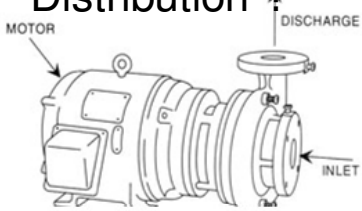
HVAC Mechanical System Functions

All-Water HVAC System



Source ?

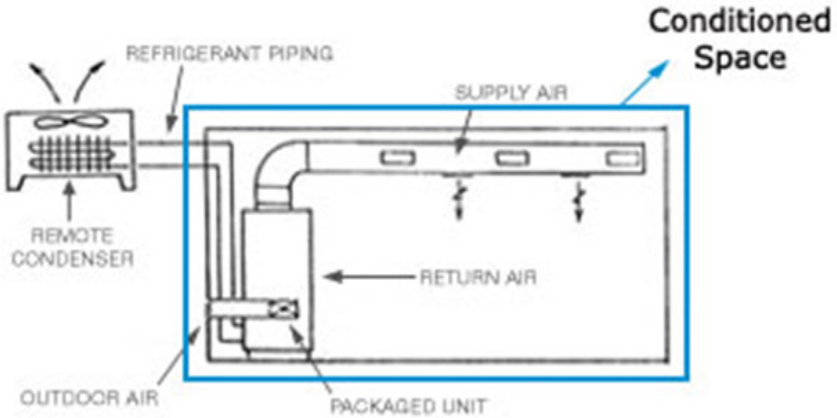
Distribution ?



Terminal ?

HVAC Mechanical System Functions

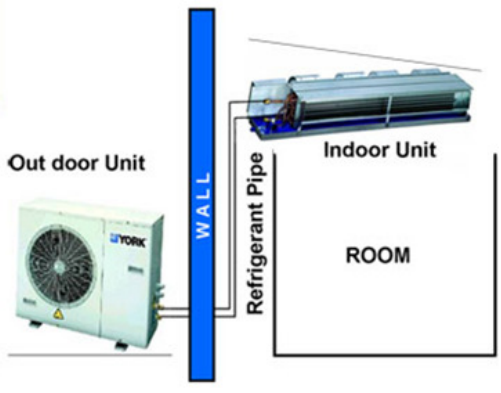
Refrigerant Direct Expansion HVAC System



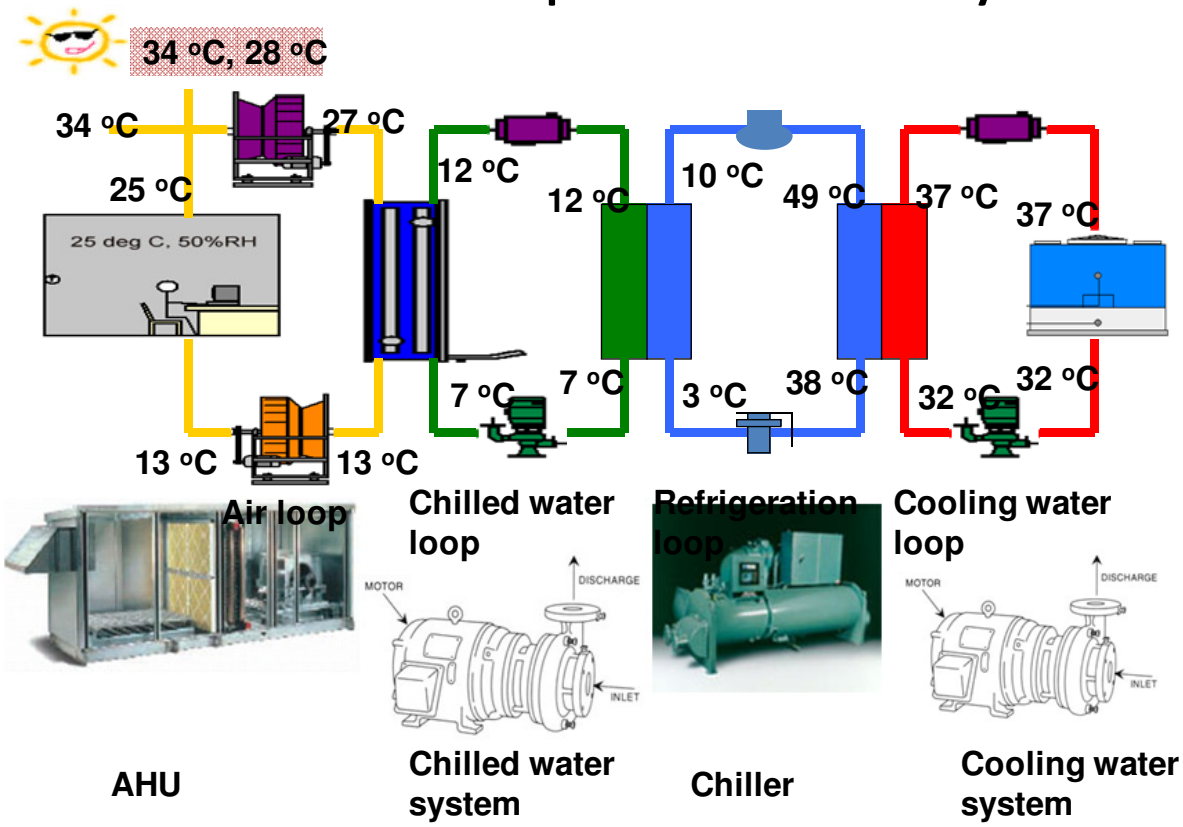
Source?

Distribution?

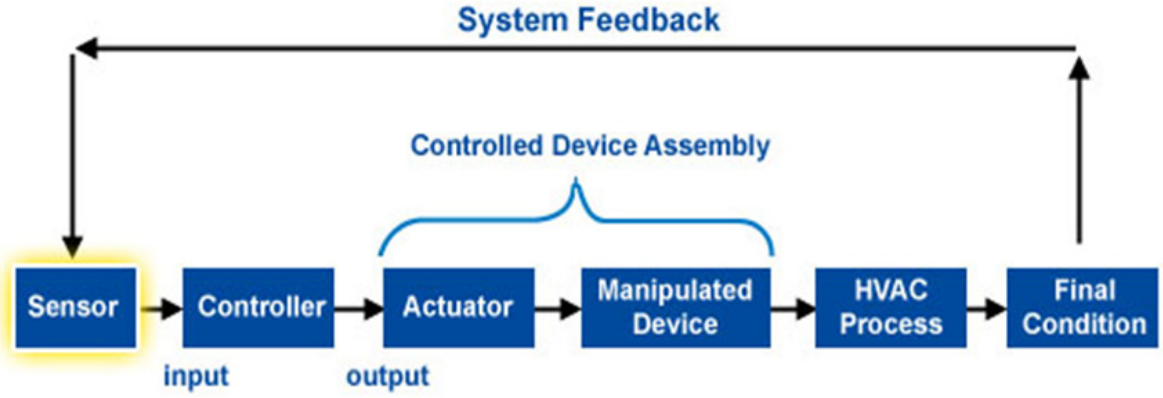
Terminal?



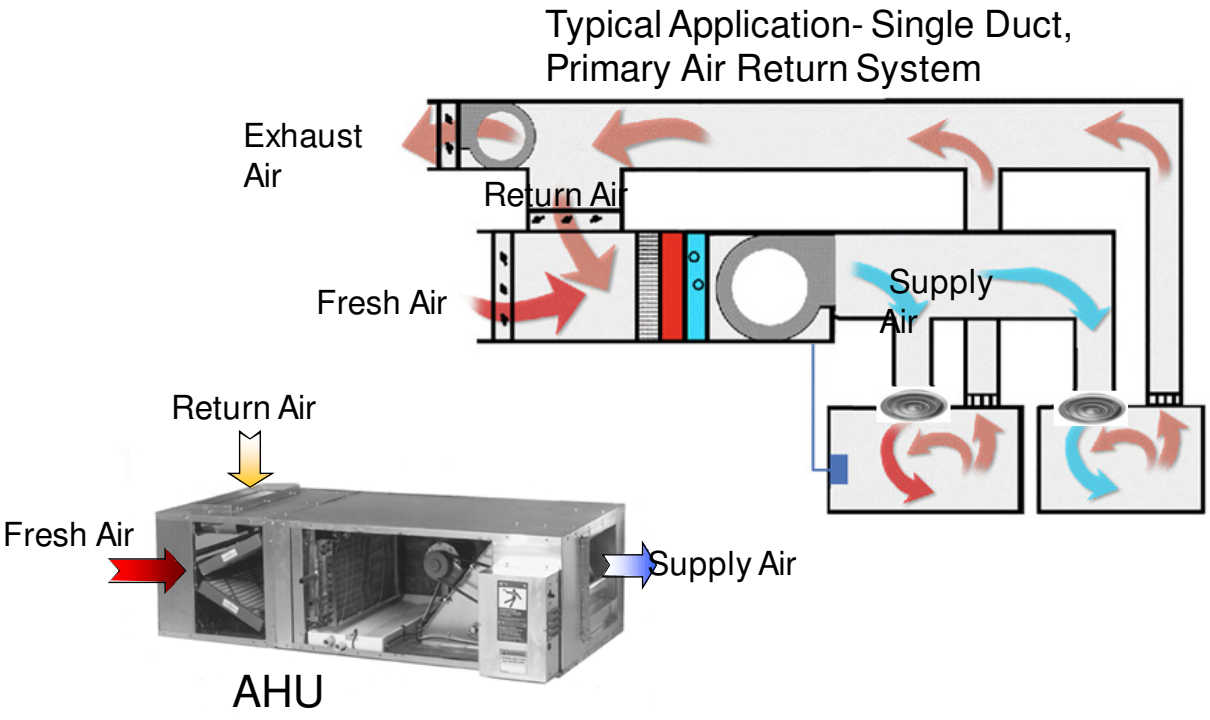
HVAC Mechanical Loops for All Air HVAC System



Information Flow of a Control Loop

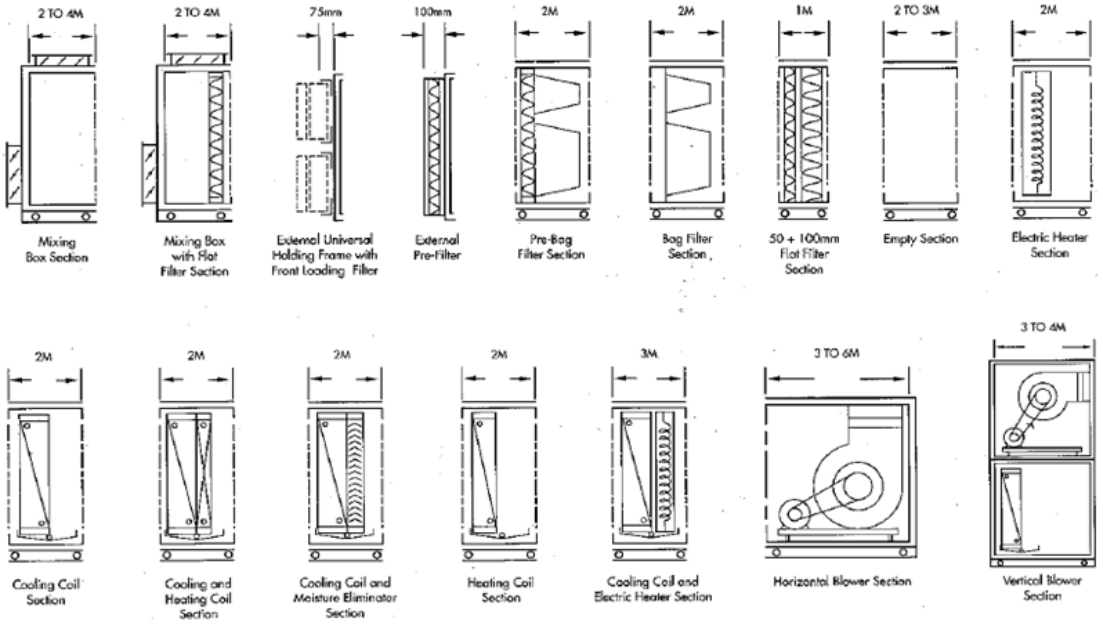


All- Air HVAC System - Typical Application



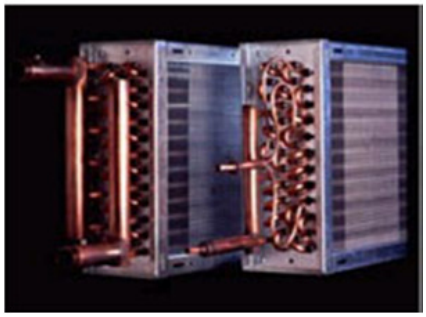
All- Air HVAC System – Key Equipment AHU

Functional Section of AHU



All- Air HVAC System – Key Equipment AHU

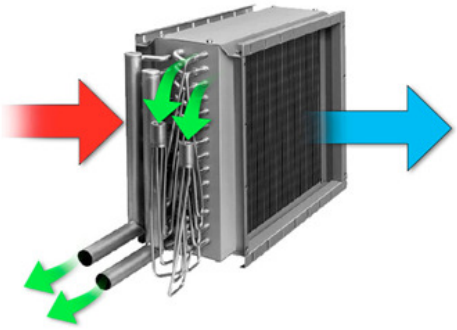
Heating and Cooling Coils

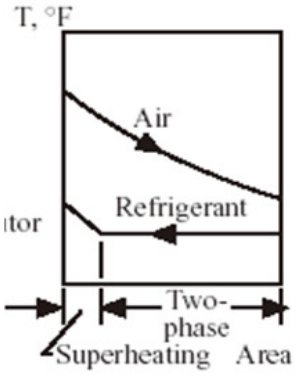


Coils:

- Indirect contact heat exchangers.
- Heat transfer between air flowing over the coil and water, refrigerant, steam or brine insider the coil.
- Fins: extended surfaces.
- Water circuits- number of water flow passages.

All- Air HVAC System – Key Equipment AHU

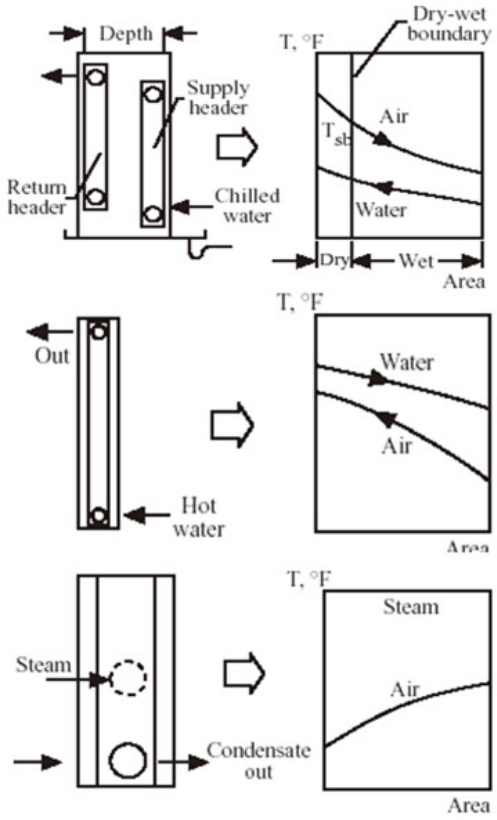




Direct expansion (DX) coil

- Refrigerant is fed (e.g. R-22 and R-134a)
- Air and refrigerant flow-usually counterflow and cross flow
- Typical evaporating temperature = 3-10 °C
- Condensate drain pan (to collect condensation)
- Performance factors: Face velocity, heat transfer coefficients, air-side pressure drop, physical size

All- Air HVAC System – Key Equipment AHU



Water cooling coils

- Chilled water flowing at 4-10°C
- Brine or glycol-water at 1-4 °C
- Temperature rise (typical) = 7-14 °C

Water heating coils

Steam heating coil

All- Air HVAC System – Key Equipment AHU

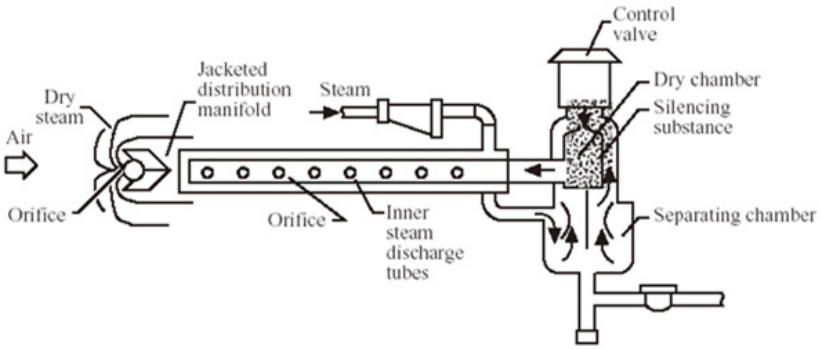
Air filters

- Air cleaning and filtration
- Operating performance:
  - Efficiency or effectiveness of dust removal
  - Dust holding capacity
  - Initial & final pressure drop
  - Service life
- Types: low, medium, and high efficiency filters + carbon activated filters

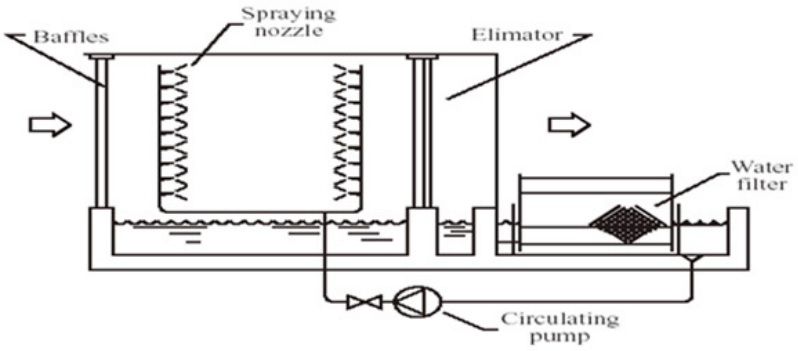
All- Air HVAC Svstem – Kev Equipment AHU

Humidifiers

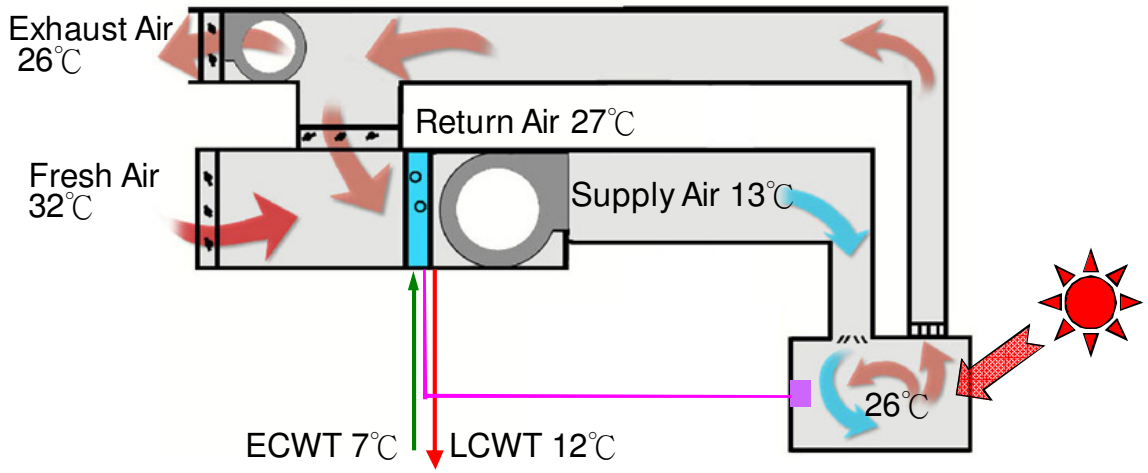
Steam humidifiers



Air washers



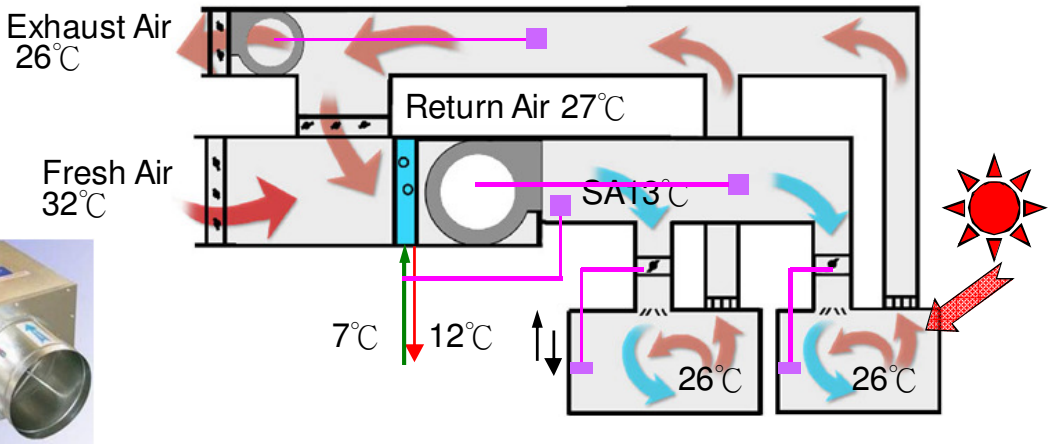
All- Air HVAC System – Constant Air Volume (CAV) System



How is indoor environment controlled?

- The supply air flow rate keeps the same
- Chilled water flow rate in AHU cooling coil is controlled by room temperature

All- Air HVAC System – Variable Air Volume (VAV) System



How is indoor environment controlled?

- Air is supplied with constant temperature.
- VAV box adjust supply air flow rate according to load need.
- Chilled water flow rate in AHU coil is controlled by supply air temperature.
- AHU fan speed is controlled to maintain proper pressure in ducts.
- Exhaust fan speed is controlled to maintain proper pressure in rooms.

All- Air HVAC System – Advantage and Disadvantage

Advantages:

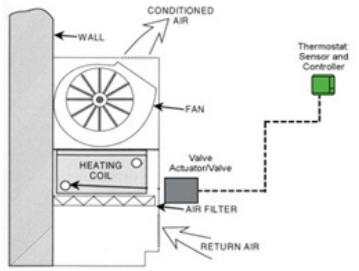
- Treat air in centralized way- more energy efficient in air treating, no condensed water in room, easier humidity control, simple seasonal changeover.
- Equipment are located in unoccupied areas- easier for operating, maintenance and noise control.
- Supply air into room- readily adaptable to ventilation, zones pressure control, and heat recovery system.
- Supply air into room- good design flexibility for indoor air distribution.

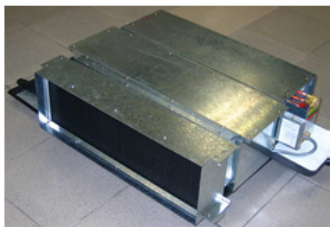
Disadvantages:

- Duct occupied large space- reduce usable ceiling/floor space.
- For CAV system, individual control are not easy to achieve.

All- Water HVAC System – Key equipment

Fan Coil- terminal unit of AWHS for heating, cooling, dehumidifying.

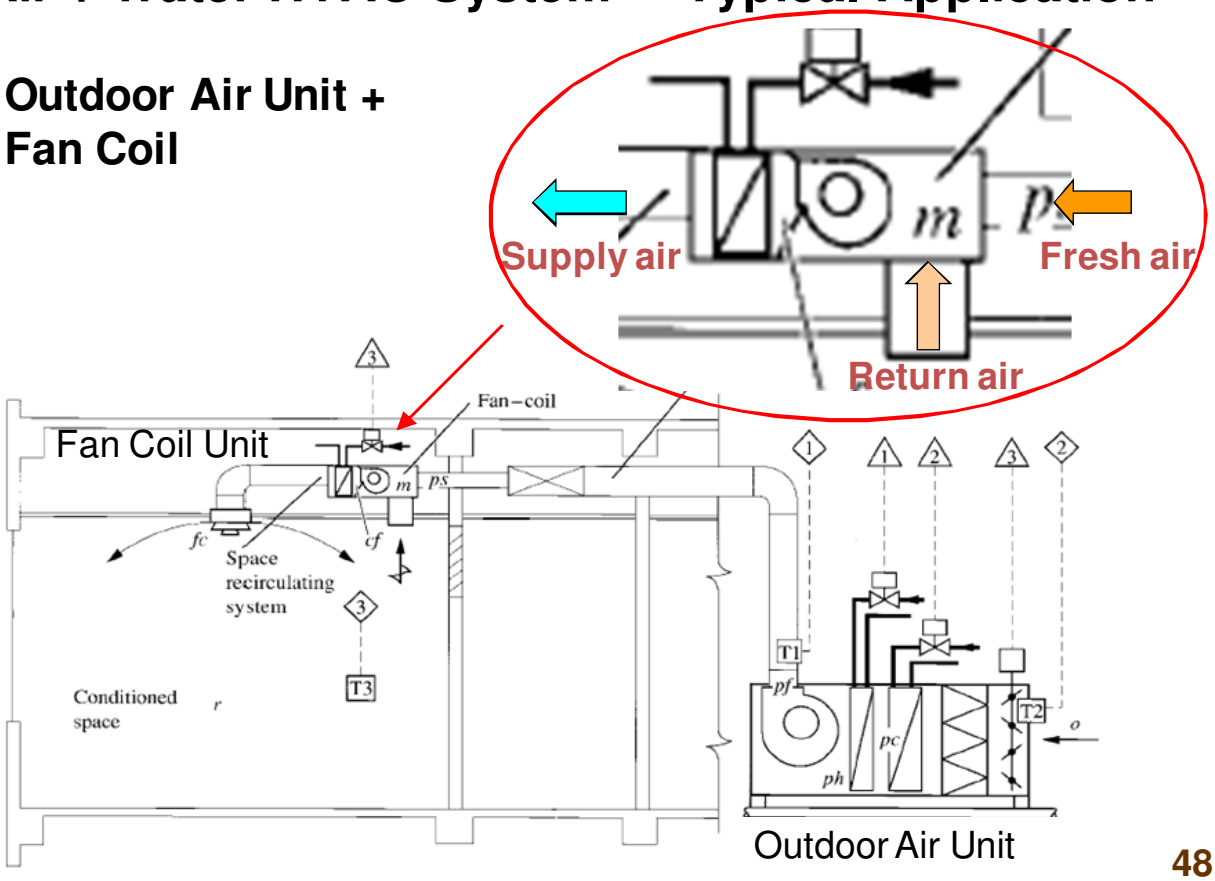




- Fan Coils consist of a fan, motor, coil, cabinet and drain pan.
- Room temperature is controlled by adjusting cooling/heating water flow rate.
- As no fresh air is introduced into room, air cleaning method to improve IAQ may be used.
  - **Filter-** provides a physical barrier to trap tiny elements such as air particles and dust mites.
  - **Biological cleaning** - TiO_2 photo catalytic oxidation can be used to decompose air pathogens like bacteria, viruses, and volatile organic compounds into CO_2 and H_2O.

Air + Water HVAC System – Typical Application

Outdoor Air Unit + Fan Coil



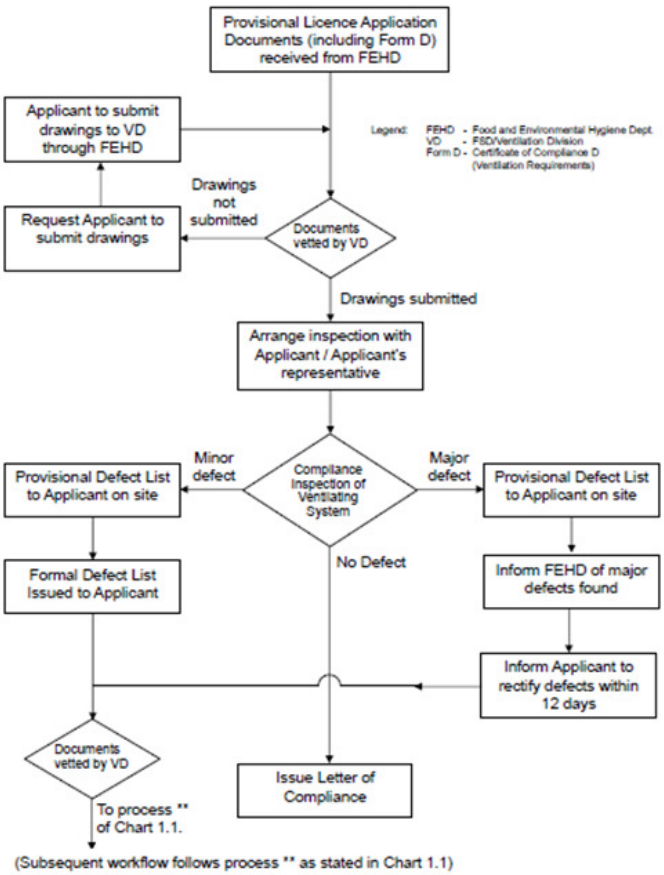
Regulations related to MVAC in Hong Kong

A Guide to

Application for Letter of Compliance

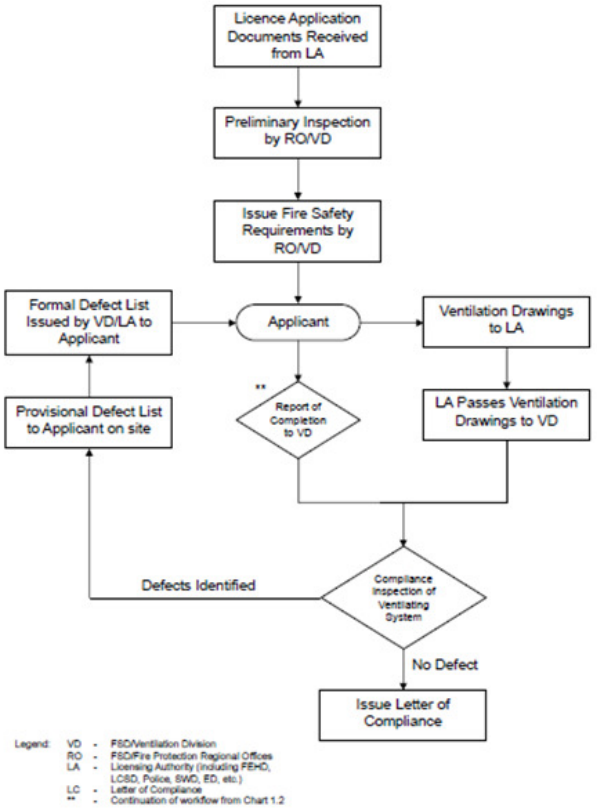
for Ventilating System

CHART 1.2 **Workflow for Licensing Inspection of Ventilating System (Provisional Licence)**



Appendix 1

CHART 1.1 **Workflow for Licensing Inspection of Ventilating System (Scheduled Premises & Non-Scheduled Premises)**



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消 防 處
牌 照 及 審 批 總 區

新界葵涌興偉路 86 號
消防處葵涌辦公大樓 3 樓

FIRE SERVICES DEPARTMENT
LICENSING & CERTIFICATION COMMAND
3/F, Fire Services Department
Kwai Chung Office Building
86 Hing Wai Road, Kwai Chung, N.T.

本處檔號 Our Ref.: FP 33/
來函檔號 Your Ref.:
傳真 Fax: (852) 2382 2495
電話 Tel. No.: (852) 2718 7567
電郵 e-mail: frvent@hkfsd.gov.hk

By Registered Mail

Dear Sir/Madam,

LETTER OF COMPLIANCE FOR VENTILATING SYSTEM INSTALLED IN SCHEDULED PREMISES

Owner : _____

Premises : _____

Address : _____

The ventilating system installed at the above premises was inspected on _____ by officers of this Department and at the time of inspection it was found in compliance with our fire safety requirements for ventilating system.

You are hereby reminded that under Section 6 of the Ventilation of Scheduled Premises Regulation, Cap. 132CE, Laws of Hong Kong, there are certain obligations, in respect of the ventilating systems installed in scheduled premises, which require your attention. Relevant particulars and advice are given in the enclosed attachment.

Yours faithfully,

( )

for Director of Fire Services

3. Types of Applications Requiring the Issue of Letter of Compliance (Ventilating System)

Licensing Authorities	Legislations	Type of Licence
FEHD	Food Business Regulation, Cap. 132X	General Restaurant
		Light Refreshment Restaurant
		Factory Canteen
		Food Factory
		Bakery
	Karaoke Establishments Ordinance, Cap. 573	Karaoke Establishment Permit In Restaurant
	Places of Public Entertainment Ordinance, Cap. 172	Places of Public Entertainment / Cinema / Theatre / Dancing Establishment
HKPF	Massage Establishments Ordinance, Cap. 266	Massage Establishment
LCSD	Places of Amusement Regulation, Cap. 132BA	Billiard Establishment / Public Bowling Alley / Public Skating Rink
SWD	Child Care Services Ordinance, Cap. 243	Child Care Centre
TELA	Amusement Game Centres Ordinance, Cap. 435	Amusement Game Centres
HAD	Hotel and Guesthouse Accommodation Ordinance, Cap. 349 Clubs (Safety of Premises) Ordinance, Cap. 376	Hotel / Guesthouse / Club house

Abbreviations :

FEHD - Food and Environmental Hygiene Department
HKPF - Hong Kong Police Force
LCSD - Leisure and Cultural Services Department
SWD - Social Welfare Department
TELA - Television and Entertainment Licensing Authority
HAD - Home Affairs Department

- Ventilating system comprises of air blower and air duct to maintain air movement in an indoor environment.
- Filter and/or electrostatic precipitator installed in the system will filter the air passing through them so as to improve the air quality.
- When an air duct passes through compartment walls/floors, fire dampers shall be fitted in the duct to curb the spread of
- fire and smoke.
- The Building (Ventilating Systems) Regulations, Cap. 123J, apply to every ventilating system that embodies the use of ducting or trunking which passes through any wall and floor of the building in which the ventilating system is installed.
- Whereas the Ventilation of Scheduled Premises Regulation, Cap. 132CE, applies to ventilating system in Scheduled Premises (i.e. general restaurant, factory canteen, dancing hall, cinema, theatre and funeral parlour).

CODES OF PRACTICE

FOR

MINIMUM FIRE SERVICE INSTALLATIONS

AND EQUIPMENT

AND

INSPECTION, TESTING AND MAINTENANCE OF

INSTALLATIONS AND EQUIPMENT

April 2012

Checklist for Actuating Devices and Operation of Fire Shutter

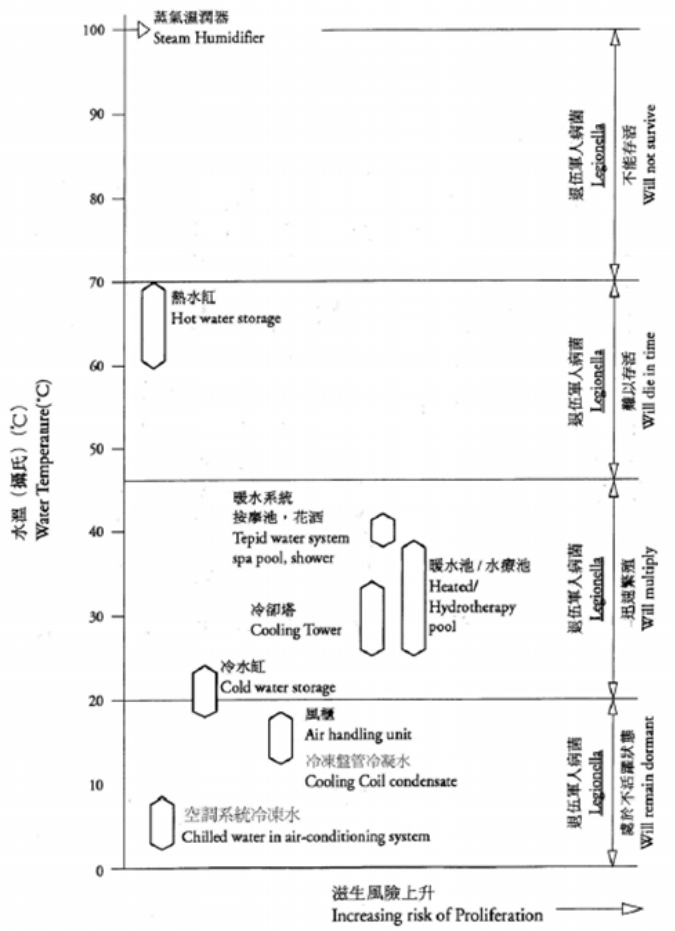
I. *REFERENCE*

Project ..... FSD Ref. .....
Address ..... Location .....
....
LPC Ref. ..... Maker's Name .....

II. *TYPE*

Single Steel Rolling Shutter	[ ]
Double Steel Rolling Shutter	[ ]
Push-up Type with Lifting Handle	[ ]
Sliding Shutter	[ ]
With Mechanical Gearing	[ ]

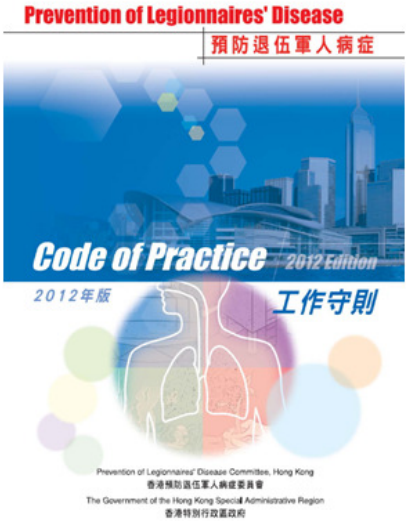
III. *INSTALLATION*		Yes	No	Remarks
3.1	Where automatic self-closing devices are fitted, do they cause no interference to the manual opening and closing of the shutter?	[ ]	[ ]	.....
3.2	Where smoke detectors are provided for the actuation of the shutter, are they fitted to both sides of the wall opening?	[ ]	[ ]	.....
3.3	Are smoke detectors installed as far as practicable to the provisions of the BS 5839-1:2002+A2:2008?	[ ]	[ ]	.....
3.4	Is permanent nameplate with adequate information provided?	[ ]	[ ]	.....
3.5	Are manual controls provided to both sides of the wall opening?	[ ]	[ ]	.....
IV. *SHUTTER OPERATION*				
4.1	Does the automatic actuation device function satisfactorily?	[ ]	[ ]	.....
4.2	Is secondary source of electricity supply provided?	[ ]	[ ]	.....
4.3	Is the descending speed* of the shutter acceptable?	[ ]	[ ]	.....



3.5 There were 150 reported cases of LD between 1994 and 2011. All were sporadic cases with no evidence of clustering. Table 1 shows a summary of the cases.

Table 1: Summary of Notified Cases of Legionnaires' Disease 1994 – 2011

Year	No. of Cases	Year	No. of Cases
1994	3	2003	3
1995	1	2004	3
1996	2	2005	11
1997	2	2006	16
1998	1	2007	11
1999	1	2008	13
2000	2	2009	37
2001	3	2010	20
2002	4	2011	17



2.1 LD typically manifests as severe pneumonia, with patients presenting symptoms of malaise, muscle pains, cough, breathlessness, headache and fever, often culminating in respiratory failure. The disease has an incubation period of 2 to 10 days.

2.2 The bacteria that cause LD are small coccobacilli measuring up to 0.5μm by 1-3μm, with occasional longer forms of 10-15μm or more, within the genus Legionellae. Over 42 species of Legionellae have been identified and the *Legionella pneumophila* serogroup 1 is most commonly responsible for LD outbreaks.

2.3 Legionellae survive and multiply in natural fresh water, including lakes, rivers, streams, ponds, mud and soil, as well as man-made water systems. The optimum temperature for proliferation of the bacteria is around 20°C to 45°C, and particularly in the range of 35°C to 43°C. The proliferation ceases above 46°C and below 20°C, while the survival time decreases to a few minutes at above 60°C. At 70°C the organism is killed virtually instantaneously.

2.4 The organism appears to be insensitive to pH but requires as nutrition the presence of simple organic life (such as algae and microorganism in sludge, scale, biofilm, etc.), inorganic substances (such as nitrogen based substances, small concentration of iron, zinc, etc. in fresh water piping systems), and organic substances (such as certain types of rubber) for survival. Nevertheless the bacteria can hardly survive in salt water and domestic water supplies which are well chlorinated.

Noise Control Ordinance

General

The purpose of the Noise Control Ordinance Cap.400 (NCO) is to provide statutory controls to restrict and reduce the nuisance caused by environmental noise.

Details of the ordinance and related regulations can be found in the "Bilingual Laws Information System" website of the Department of Justice at www.legislation.gov.hk.

The NCO deals with the following forms of noise:

(a) noise from domestic premises and public places (often referred to as general neighbourhood noise);

(b) noise from construction activities (including piling);

(c) noise from places other than domestic premises, public places or construction sites (for example, noise from industrial or commercial premises);

(d) noise from intruder alarm systems (installed in any premises or vehicles);

(e) noise from individual items of plant or equipment (referred to in the Ordinance as Product Noise, for example, noise from hand-held breaker and air compressor); and

(f) noise emission from motor vehicles (requiring noise emission from motor vehicles to comply with stringent international standards on first registration in Hong Kong).

Noise from Places other than Domestic Premises, Public Places or Construction Sites

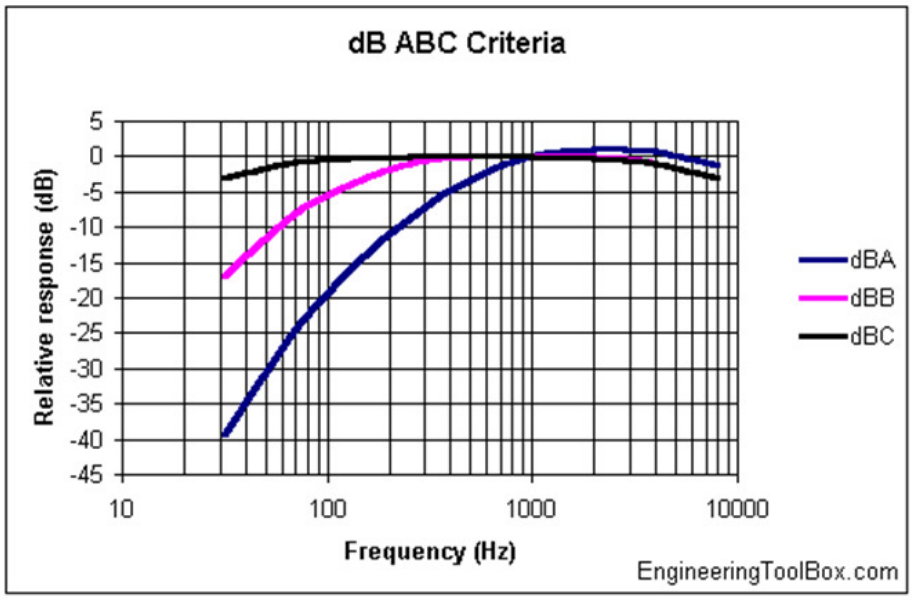
This kind of noise is also called industrial/commercial noise. Examples are noise from factories, ventilating systems of restaurants, noise from car repairing in garages and so on.

These photographs show some examples of industrial/commercial noise :

Comparing dB(A), dB(B) and dB(C)

The decibel filters A, B and C are compared below:

Relative Response (dB)	Frequency (Hz)								
	31.5	63	125	250	500	1000	2000	4000	8000
dB(A)	-39.4	-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1
dB(B)	-17	-9	-4	-1	0	0	0	-1	-3
dB(C)	-3	-0.8	-0.2	0	0	0	-0.2	-0.8	-3

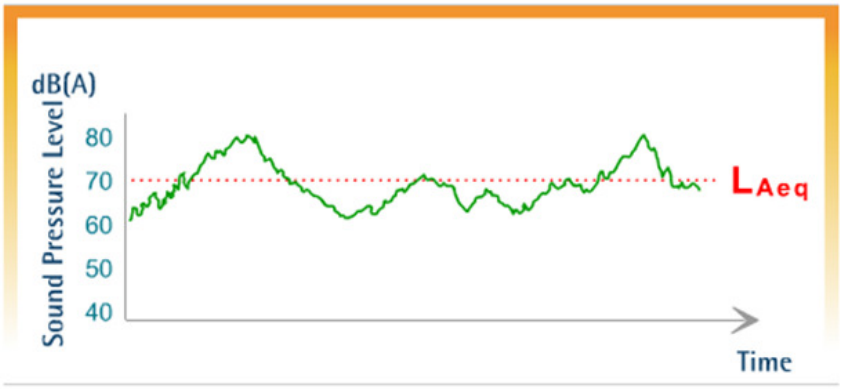


Equivalent Continuous Sound Pressure Level, L_{eq}

This is a widely used noise descriptor that is commonly adopted in many developed countries. It is the constant noise level which, under a given situation and time period, contains the same acoustic energy as the actual time-varying noise level. As L_{eq} measures the energy content of a noise over a period of time, noise with different characteristics, such as fluctuating (e.g. from traffic) or impulsive noise (e.g. from hammering) as described in the next section, can give the same L_{eq} Level.

When noise or sound is measured in dB(A), it is customary to denote the equivalent continuous sound pressure level as L_{Aeq}.

Let us explain L_{eq} or L_{Aeq} by using an illustration. Please click on the demo button to see the details.



IAQ Parameters

14. A total of 12 IAQ parameters as listed in Table 1 shall be measured. These include 3 physical parameters (room temperature, relative humidity, and air movement), 8 chemical parameters (carbon dioxide (CO_2), carbon monoxide (CO), respirable suspended particulates (PM_{10}), nitrogen dioxide (NO_2), ozone (O_3), formaldehyde (HCHO), total volatile organic compounds (TVOC), and radon (Rn)), and 1 biological parameter (airborne bacteria). We will also include an additional parameter, airborne fungi with an indicative level of 500 cfu/m^3, for both "Good" and "Excellent" Classes in the next review for the Certification Scheme.

Sampling Criteria

15. Measurement should not be made in any part of the premises/building where it is totally enclosed but not served by MVAC system, such as store rooms, plant rooms, switch rooms, or kitchens (in the case of restaurants), etc.

Sampling Period

16. Measurement should be made on an 8-hour basis except otherwise specified. Where it is not practicable to take 8-hour continuous measurement, surrogate measurement (i.e. an intermittent measurement strategy based on the average of half-hour measurements conducted at four time-slots) is accepted. Competent examiners should take into account the operation pattern of the premises/building when choosing the four time-slots. As a guideline, the four time-slots should be evenly distributed over the business hours for office buildings whereas for public places they should cover the worst-case scenario such as periods of highest occupancy.

TABLE 1: IAQ OBJECTIVES FOR OFFICES & PUBLIC PLACES

Parameter	Unit	8-hour average [a]	
		Excellent Class	Good Class
Room Temperature	°C	20 to < 25.5 [b]	< 25.5 [b]
Relative Humidity	%	40 to < 70 [c]	< 70
Air movement	m/s	< 0.2	< 0.3
Carbon Dioxide (CO_2)	ppmv	< 800 [d]	< 1,000 [e]
Carbon Monoxide (CO)	µg/m^3	< 2,000 [f]	< 10,000 [g]
	ppmv	< 1.7	< 8.7
Respirable Suspended Particulates (PM_{10})	µg/m^3	< 20 [f]	< 180 [h]
Nitrogen Dioxide (NO_2)	µg/m^3	< 40 [g]	< 150 [h]
	ppbv	< 21	< 80
Ozone (O_3)	µg/m^3	< 50 [f]	< 120 [g]
	ppbv	< 25	< 61
Formaldehyde (HCHO)	µg/m^3	< 30 [f]	< 100 [f, g]
	ppbv	< 24	< 81
Total Volatile Organic Compounds (TVOC)	µg/m^3	< 200 [f]	< 600 [f]
	ppbv	< 87	< 261
Radon (Rn)	Bq/m^3	< 150 [i]	< 200 [f]
Airborne Bacteria	cfu/m^3	< 500 [j, k]	< 1,000 [j, k]

ANNEX 4

Certificate No.
證書編號 : _____

Indoor Air Quality Certificate
(Excellent Class)
室內空氣質素檢定證書《卓越級》

Valid period
有效日期 : _____ to 到 _____

I hereby certify that the indoor air quality of the following location(s) has fully complied with the Excellent Class of the Indoor Air Quality Objectives.
本人證明下列地點的室內空氣質素完全符合「卓越級」室內空氣質素指標。

Name of building
建築物名稱 : _____
Address
地址 : _____

Certified location(s)
已檢定地點 : _____

SAMPLE

Competent Examiner
合資格檢驗師

Name
姓名 : _____
Organisation
所屬機構 : _____
Signature
簽署 : _____
Date of issue
簽發日期 : _____

Organisation Chop
機構印鑑

Indoor Air Quality Certification Scheme for Offices and Public Places
辦公室及公眾場所室內空氣質素檢定計劃

Indoor Air Quality Information Centre
室內空氣質素資訊中心

Hotline 熱線: 2786 6177
Webpage 網址: http://www.iaq.gov.hk/

ARCHITECTURAL SERVICES DEPARTMENT
BUILDING SERVICES BRANCH

GENERAL SPECIFICATION FOR AIR-CONDITIONING, REFRIGERATION, VENTILATION AND CENTRAL MONITORING & CONTROL SYSTEM INSTALLATION IN GOVERNMENT BUILDINGS OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION
2007 EDITION

Corrigendum No. GSAC01
(December-2010)

A2.1 STATUTORY OBLIGATIONS AND OTHER REQUIREMENTS

A2.1.2 Other Requirements

(h) Design Manual: Barrier Free Access 2008 published by the Buildings Department, the Government of the HKSAR;

(i) Codes of Practice on Prevention of Legionnaires' Disease published by the Prevention of Legionnaires' Disease, Hong Kong (2007 Edition);

(j) Codes of Practice issued by the following international institutions:-

- American National Standard Institute
- Air-conditioning and Refrigeration Institute
- American Society of Mechanical Engineers
- American Society of Testing and Materials
- Committee for European Normalisation
- The Institute of Electrical and Electronic Engineers
- International Organisation for Standardisation
- Japanese International Standard
- National Fire Protection Association;

(k) The Supply Rules and other requirements issued by the relevant local electricity supplier and water authority;

(l) Technical Memorandum to issue Air Pollution Abatement Notice to control Air Pollution from Stationary Processes;

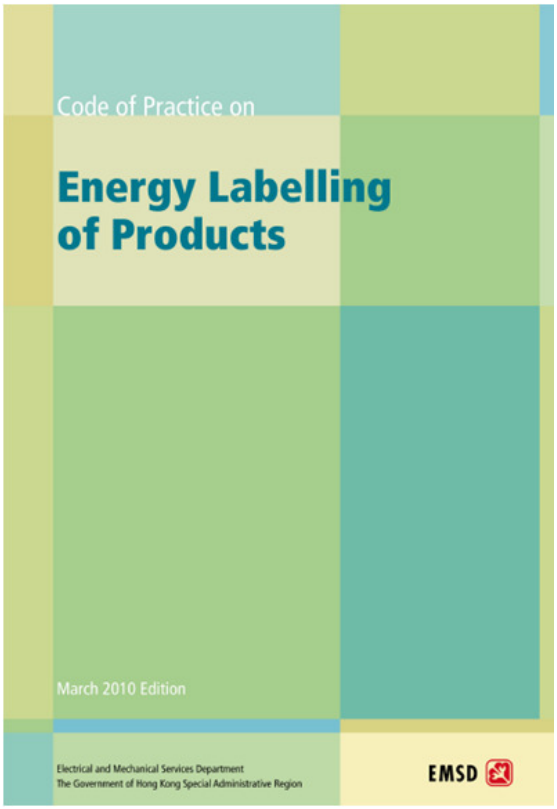
(m) Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites;

(n) Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste;

(o) Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes;

(p) Technical Memorandum - Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters; and

(q) Technical Memorandum on Environmental Impact Assessment Process.



Classification of Room Air Conditioners

All room air conditioners regulated under the Ordinance are classified in accordance with Table 7.1—

Table 7.1 – Overall classifications

Type	Function	Category	Description
Single Package	Cooling Only	Category 1	A single package type room air conditioner with cooling function only
	Reverse Cycle	Category 2	A single package type room air conditioner with both cooling and heating functions
Split	Cooling Only	Category 3	A split type room air conditioner with cooling function only
	Reverse Cycle	Category 4	A split type room air conditioner with both cooling and heating functions

Room Air Conditioner Category	Average Appliance Energy Consumption (kW)
Category 1 & 2	$E_{av} = 0.442 \times \Phi_c$
Category 3 & 4	$E_{av} = 0.387 \times \Phi_c$

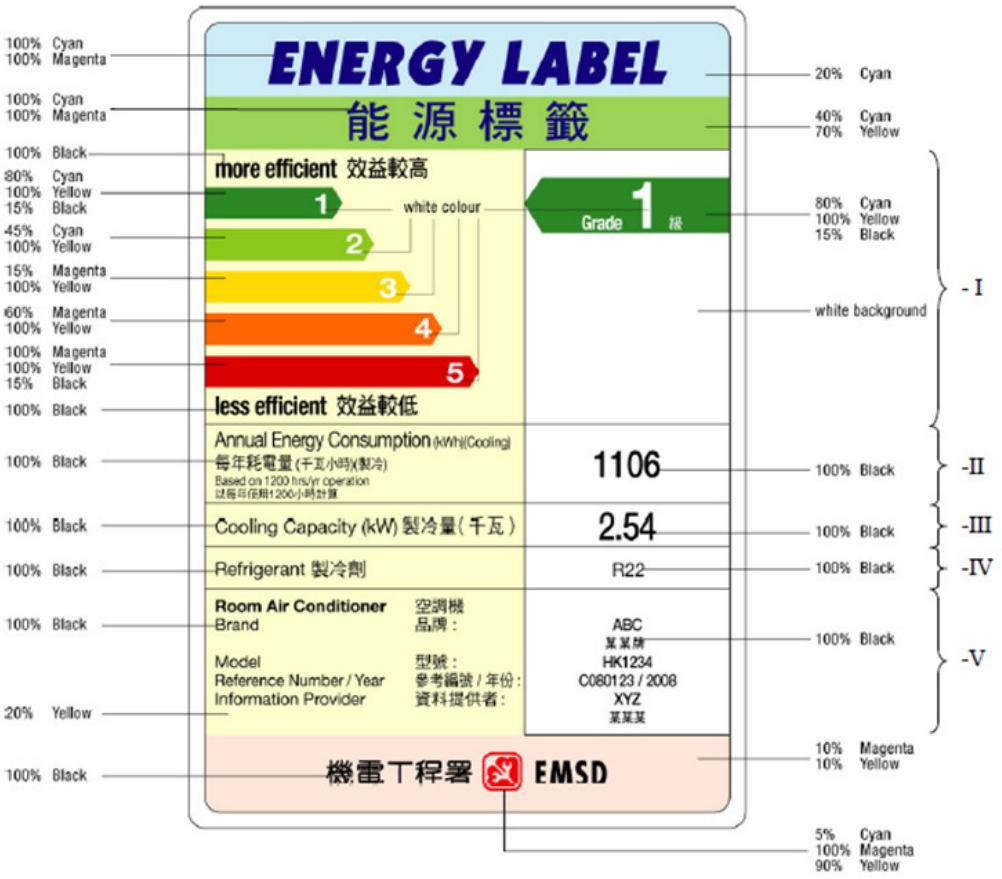
Where Φ_c is the measured cooling capacity defined in clause 7.5.3 of the Code.
E_{av} is the average appliance energy consumption expressed in kW.

The energy consumption index ($I\varepsilon$) of a room air conditioner is defined as the ratio of the actual effective power input (P_E) of the room air conditioner to the Average Appliance Energy Consumption (E_{av})

$$\text{Energy Consumption Index } (I_\varepsilon) = \frac{P_E}{E_{av}} \times 100\%$$

Table 7.4 – Derivation of energy efficiency grades

Energy Consumption Index I_ε (%)	Energy Efficiency Grade *(Note)*
$I_\varepsilon \leq 85$	1
$85 < I_\varepsilon \leq 95$	2
$95 < I_\varepsilon \leq 105$	3
$105 < I_\varepsilon \leq 120$	4
$120 < I_\varepsilon$	5



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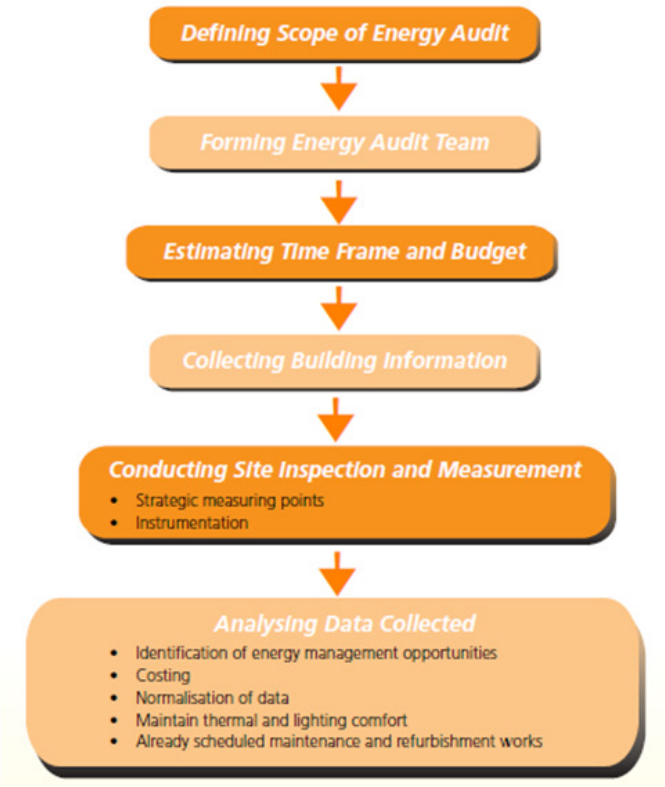
Guidelines on
Energy Audit

Electrical & Mechanical Services Department

The Government of the
Hong Kong Special Administrative Region

2007

Figure 1: Flow Chart on Conducting Energy Audit



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At this stage of the audit, the auditor should be able to tell the characteristics of the energy consuming equipment/systems such as:-

a) Type of chillers, their capacities and operational characteristics (refrigeration pressure/temperature, water flow rate/temperature/pressure, etc.);

b) Type of HVAC systems, their components (fans, pumps, pipework, ductwork, etc.) and operating characteristics (flow rate, temperature, pressure, etc.);

c) Occupancies or usage for various equipment/systems;

d) Control mechanisms for various equipment/systems (controller, actuator, sensor, control logic, etc.);

e) Type of luminaires, their characteristics and control mechanisms;

f) Power distribution system characteristics;

g) Operational characteristics of lift and escalator installation (zoning, type of motor drive, control mechanism, etc.);

h) Operational characteristics of other energy consuming equipment/systems; and

i) Characteristics of the building.

a) Chiller efficiency (Coefficient of Performance)

b) Motor efficiency (%)

c) Fan system power (kW per L/s of supply air quantity)

d) Fan efficiency (%)

e) Piping system frictional loss (Pa/m)

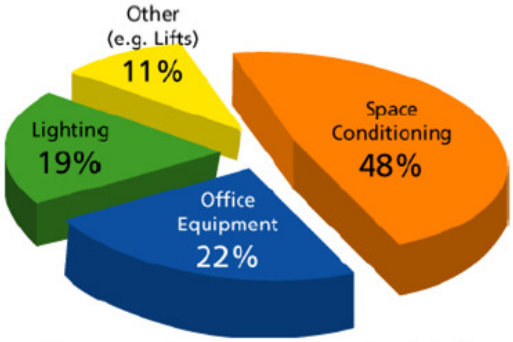
f) Pump efficiency (%)

g) Lighting power density (W/m^2)

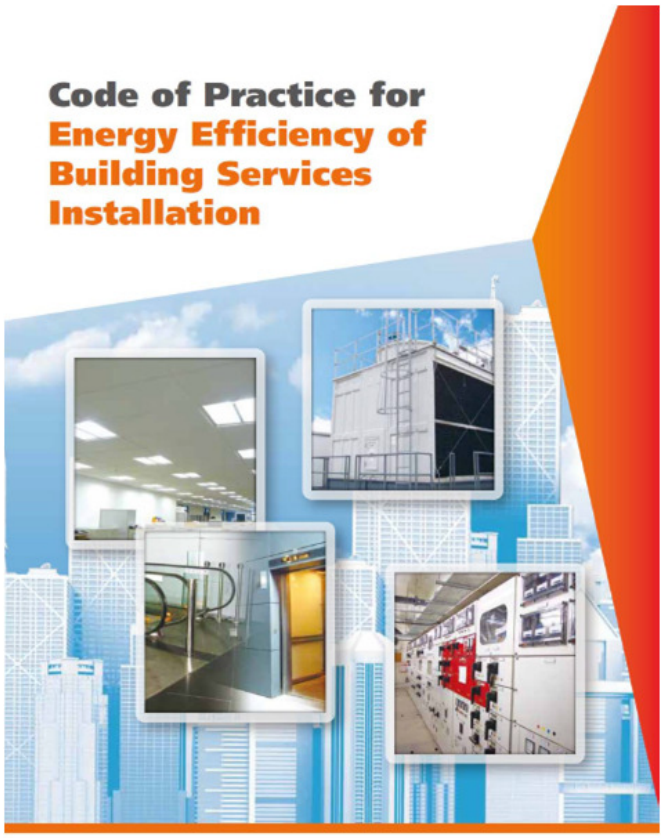
h) Lamp luminous efficacy (Lm/W)

i) Lamp control gear loss (W)

j) Efficiencies of various equipment e.g. boiler, heat pump, etc (%)



Different proportion of energy consumption of a building



For the purposes of:

- Encouraging proper sizing of equipment pinpointing design conditions.
- Reducing air side distribution losses, ductwork leakage and fan power.
- Reducing water distribution losses and pipe friction loss.
- Reducing allowable coefficients of performance.
- Reducing conduction losses in pipework, ductwork and AHUs.
- Reducing the use of energy through efficient controls and monitoring of power consumption.

Table 6.4 : Air-conditioning System Load Design Conditions				
Condition	Season	Applications	Temperature / Relative Humidity	
Indoor, for human comfort applications	Summer	Office and Classroom	Minimum dry bulb temperature	23°C
			Minimum relative humidity	50%
		Other applications	Minimum dry bulb temperature	22°C
			Minimum relative humidity	50%
	Winter	Hotel	Maximum dry bulb temperature	24°C
			Maximum relative humidity	50%
		Other applications	Maximum dry bulb temperature	22°C
			Maximum relative humidity	50%
Outdoor	Summer	All applications	Maximum dry bulb temperature of 35°C with wet bulb temperature lower than 29°C, or Maximum wet bulb temperature of 29°C with dry bulb temperature lower than 35°C	
	Winter	All applications	Minimum dry bulb temperature	7°C

A process zone refers to a zone meeting a process requirement or serving as a computer/data centre with special temperature and/or humidity requirements, and its serving air distribution system should be dedicated to serve the process zone only and be separate from other system serving comfort only zone.

Table 6.6 : Air Leakage Limit of Ductwork		
Leakage Class	Operating Static Pressure (Pa)	Air Leakage Limit (L/s per m^2 of duct surface)
I	above 750 to 1000	$0.009 \times p^{0.65}$
II	above 1000 to 2000	$0.003 \times p^{0.65}$
III	above 2000	$0.001 \times p^{0.65}$
Remark: p is the operating static pressure in Pascal		

6.7.1 The system fan motor power required for a constant air volume air distribution system for a conditioned space should not exceed a limit of 1.6 W per litre per second (L/s) of supply system air flow.

6.7.2 The system fan motor power required for a variable air volume air distribution system for a conditioned space should not exceed a limit of 2.1 W per L/s of supply system air flow.

Water piping with diameter larger than 50 mm should be sized for frictional loss not exceeding 400 Pa/m and water flow velocity not exceeding 3 m/s. Water piping with diameter 50 mm or below should be sized for flow velocity not exceeding 1.2 m/s.

Temperature controls, humidity controls, zone control, off-hours control.

Table 6.11a : Minimum Insulation Thickness for Chilled Water Pipework [@1]

Ambient Condition	Outdoor [@2]				Unconditioned Space [@2]				Conditioned Space [@2]	
Thermal conductivity λ (W/m-°C) [@3]	0.024		0.04		0.024		0.04		0.024	0.04
Surface coefficient h (W/m²-°C) [@4]	9	13.5	9	13.5	5.7	10	5.7	10	any value	
Pipe outer diameter d_o [@1]	Insulation thickness (mm) [@1]									
21.3 mm	20	15	30	22	29	19	43	28	13	13
26.9 mm	21	15	32	23	31	20	46	29	13	13
33.7 mm	22	16	34	24	32	21	48	31	13	13
42.4 mm	23	17	35	25	34	21	50	32	13	25
48.3 mm	24	17	36	26	35	22	52	33	13	25
60.3 mm	25	18	38	27	36	23	54	35	13	25
76.1 mm	26	18	40	28	38	24	57	36	14	25
88.9 mm	26	19	41	29	39	24	59	37	14	25
114.3 mm	27	19	42	30	41	25	62	39	14	25
139.7 mm	28	20	44	31	42	26	64	40	14	25
168.3 mm	29	20	45	32	43	26	66	41	14	25
219.1 mm	29	20	47	32	44	27	69	42	15	25
273 mm	30	21	48	33	45	27	71	43	15	25
323.9 mm	30	21	49	34	46	28	73	44	15	25
355.6 mm	31	21	49	34	47	28	74	45	15	25
406.4 mm	31	21	50	34	47	28	75	45	15	25

Table 6.12b : Minimum Coefficient of Performance for Chiller[@2] at Full Load

Air-cooled

Type of compressor	Reciprocating		Scroll	Screw	Centrifugal
Capacity Range (kW)	Below 400 kW	400 kW & above	All Ratings	All Ratings	All Ratings
Minimum COP at cooling (free air flow[@1])	2.6	2.8	2.7	2.9	2.8

Water-cooled

Type of compressor	Reciprocating			Scroll			Screw			Centrifugal		
Capacity Range (kW)	Below 500 kW	500 to 1000 kW	Above 1000 kW	Below 500 kW	500 to 1000 kW	Above 1000 kW	Below 500 kW	500 to 1000 kW	Above 1000 kW	Below 500 kW	500 to 1000 kW	Above 1000 kW
Minimum COP (Cooling)	4.1	4.6	5.2	4.1	4.6	5.2	4.6	4.7	5.5	5.1	5.6	5.7

Standard rating conditions

Type of Cooling	Air-cooled			Water-cooled					
Operation condition	Condenser ambient temperature	Chilled water temperature		Condenser water temperature				Chilled water temperature	
				Fresh water		Sea water			
		In	Out	In	Out	In	Out	In	Out
	35°C	12.5°C	7°C	32°C	37°C	28°C	33°C	12.5°C	7°C
Water side fouling factor	Evaporator			$0.000018 m^2\text{-}^0C/W$					
	Condenser			Fresh water		$0.000044 m^2\text{-}^0C/W$			
				Sea water		$0.000088 m^2\text{-}^0C/W$